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Research Study 69-8

SUMMARY OF SIMPO-I MODEL DEVELOPMENT

(excerpted from Technical Research Report 1157)

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J. E. UHLANER
Director

JAMES E. WIRRICK
COL, GS
Commanding

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(6) **SUMMARY OF SIMPO-I MODEL DEVELOPMENT**
(~~excerpted from Technical Research Report~~ 1157)

(10) Pauline T. Olson, Richard C. Sorenson,
Kenneth W. Haynam, Joanne M. Witt, [redacted]
Elizabeth N. Abbe

(12) 18

Submitted by:
Cecil D. Johnson, Chief
Statistical Research and
Analysis Division

Approved by:
J. E. Uhlaner, Director
Behavioral Science
Research Laboratory

(11) May [redacted]69

Research Studies are special reports to military management. They are usually prepared to meet requests for research results bearing on specific management problems. A limited distribution is made--primarily to the operating agencies directly involved.

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FOREWORD

The BESRL Work Unit, "Computerized Models for the Simulation of Policies and Operations of the Personnel Subsystem--SIMPO-I," is conducted by the Statistical Research and Analysis Division. The task constitutes the initial undertaking of an operations research requirement described in the Army Master Study Program under the title, "A Simulation Model of Personnel Operations (SIMPO)" and is Project 2Q065101M711, "Army Operations and Intelligence Analysis," under the auspices of the Army Study Advisory Committee. Subtasks include: a) Operational Analysis of Personnel Subsystem; b) Cataloging and Integration of Existing Manpower Models; c) Development of Measures of System Effectiveness; d) Development of Modeling Techniques; e) Design and Programming of SIMPO-I; f) Application and Evaluation of Computerized Models; and g) Problem Oriented Language for Management.

The present publication, excerpted from BESRL Technical Research Report 1157 which bears the same title, indicates progress made in the production and planning of computerized models for use in dealing with problems related to the distribution and utilization of Army personnel and to career progression, reassignment, and rotation and for evaluating alternative personnel policies. The portion presented here constitutes Part I of the Report, which is now in press. In Part II the models developed to date are more fully described with special reference to their capabilities.

J. E. UHLANER, Director
U. S. Army Behavioral Science
Research Laboratory

SUMMARY OF SIMPO-I MODEL DEVELOPMENT

BRIEF

Requirement:

A computerized model simulation package is described for assessing quantitatively the cumulative impact of personnel policy changes on the allocation, distribution, and utilization of Army personnel with special attention to effects of policies on deployability.

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Research Products:

The models completed include:

DYNAMOD, consisting of four mass flow models representing varying characteristics of the Army's rotation system; while designed to deal with specific problems areas, the four models are adapted to a variety of related personnel problems.

ACCMOD, a dynamic mass flow model of the noncareer enlisted subsystem, for use in projecting accession needs.

DYROM II, a dynamic mass flow model of career (upper five) enlisted grades by which to project needed input from noncareer sources--training schools and promotion from lower grades.

Career-Noncareer Model, incorporating desirable features of the three preceding models and providing a greater number of user options.

SIMPO-I Quality Input Model. Simulation is accomplished by the flow of entities rather than by bulk flow that characterizes the above models. In this model, entities usually represent individuals rather than groups. Developed for comparison of alternative allocations of personnel for performance under varying resource conditions.

Other models in final stages of development are:

SIMPO-I GMM (General Matrix Manipulator). A related group of mass flow subroutines providing the capability of simulating many segments of the personnel subsystem. Personnel are partitioned by four measurements, at least two of which are time in state.

DISTRO. A specific application and extension of the GMM providing comprehensive coverage of the Army's personnel procurement and distribution system for estimating manpower capabilities under policy constrained deployment.

SIMPO-I GES (General Entity Simulator). An integrated package of entity subroutines providing the capability for simulating many segments of the personnel subsystem. Up to 50,000 entities and 500 nodes may be simulated at the BESRL computer installation.

Aviator Entity. A specific application of the GES designed to provide better estimates of training needs and assignment capabilities of the Army Aviator personnel system under various personnel management policies.

Utilization of Models:

DYNAMOD and the Career-Noncareer Model have been used extensively in study of the Army Aviator System. Agencies using these models have been the Capabilities and Analysis Division (CAD) and the Aviation Branch of the Directorate of Individual Training of the Office of the Deputy Chief of Staff for Personnel, the staff of the Deputy Undersecretary of the Army for Operations Research, the Executive for Army Aviation in the Office of Personnel Operations, and the Office of the Undersecretary of Defense for Systems Analysis. DYROM II and ACCMOD have been used in the regularly scheduled capabilities analysis by CAD to examine need for the Skill Development Base Program and the adequacy of projected accessions. The SIMPO-I Entry Assignment Model has been used in a study of the effects of lowering entry standards, the users being other divisions of BESRL and subsequently the Office of the Assistant Secretary of the Army for Manpower. Other models are in final stages of development and have not yet been used operationally.

SUMMARY OF SIMPO-I MODEL DEVELOPMENT

(excerpted from Technical Research Report 1157)

PART I SIMPO-I SCOPE AND PROGRESS

PURPOSE OF THE REPORT

SIMPO-I, "Computerized Models for the Simulation of Policies and Operations of the Personnel Subsystem," a U. S. Army Behavioral Science Research Laboratory work unit (manned at five scientific man-years for each of Fiscal Years 1968 and 1969), has produced a number of working models and has developed plans for others. Each model, or each family of closely related models, is documented in a report combining model description and instructions for users.

In the present overall report, the computerized models so far produced are briefly described and the differences in their capabilities are discussed. ~~The report is, of course, an interim publication, inasmuch as~~ some models are still being developed. The introductory section includes a discussion of the general concepts of models and their use in policy evaluation, and points up the philosophy behind BESRL efforts. Because of the concern of the Program to Improve Management of Army Resources (PRIMAR) with policy-resultant nondeployability, special attention has been directed toward assessment of the problem and the development of rotation/assignment models with provision for representing deployability-related variables. In this connection, a special application of a simulation technique to a distribution model (DISTRO) has been developed.

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SIMPO OBJECTIVES

The generalized research objectives are 1) to analyze the personnel subsystem from a problem-oriented point of view, determining points at which decisions are made and identifying operations which affect total system effectiveness and criteria by which policies may be evaluated; 2) to simulate personnel functions in the context of a personnel system in order to predict and assess the total result of policy changes; and 3) to provide a basis for an increasingly integrated approach to policy evaluation within the full scope of the total personnel subsystem. As noted above, the determination of policy changes on total personnel deployability and overall force readiness is a particularly important objective.

The potential military end result is a series of models and other procedures for assisting the management functions of the Office, Deputy Chief of Staff for Personnel. The procedures developed will be used to evaluate policies relating to the assignment, training, utilization, and contingency readiness of specialized personnel, including Army aviators. In broader terms, the SIMPO-I product will provide computer-aided operations research methods and tools that will increase the Army's in-house capability for responding to personnel management requirements.

MANPOWER MODELING CONCEPTS

In establishing optimal overall policies for distribution and utilization of personnel, many questions concerning personnel policy alternatives await objective evaluation. Problems related to career progression, reassignment, and rotation of personnel all must be considered. Experimental studies involving the real system are expensive not only in terms of cost of data collection, but also in terms of possible losses through inadequate policy or operational procedure in effect during the trial period. However, if the personnel system can be modeled and the policies applied in a computerized simulation of the system, evaluation of the policy alternatives or new procedure may be relatively inexpensive.

First, the general use of models in the study of manpower systems is considered briefly. In the present context, "model" refers to a logically connected set of rules that abstract selected characteristics of some phenomenon or system. The purpose of constructing such models is threefold: 1) to investigate dependencies among parameters, 2) to generate hypotheses concerning significant variables, and 3) to evaluate systems. Analysis of logical models often demonstrates that a policy is infeasible because certain configurations of parameters are inconsistent.

With regard to the second purpose, many of the systems modeled are complicated. The relationship between system variables cannot be intuitively determined, or may be determined only to the extent of direction of the relationship. By employing a model, it is possible to generate hypotheses regarding the extent and character of the relationship and factors entering into the relationship.

In the evaluation of systems, two sets of conditions are involved. For some models, the values of the parameters are given. These deterministic models have as a major subclass the data-free model in which the variables represent policies. The data-free models are concerned not with how the real system behaves, but with how the system would behave if prescribed policies were followed. The second set of conditions prevails when, instead of specifying the values of the parameters, the probability of occurrence of the various values for the parameters is specified. These models are referred to as stochastic models. It is sometimes considered a disadvantage of the latter model that considerable data collection may have to take place before distribution properties of stochastic variables may be estimated.

Since the systems are very complex, the models must be abstractions of the systems. Characteristics are selected so as to relate meaningfully to: 1) the givens (characteristics inherent in the system--for example, parameter values and rules which define the unchangeable characteristic behavior of the system), 2) policies which may be modified or manipulated, and 3) criteria of performance or effectiveness. In SIMPO manpower system models, the variables describing the state of the system may include the manpower requirements for specific categories of personnel at various stations, the characteristics of the personnel assets, and the already determined selection, classification, and rotation policies. The variables to be modified are the policy related variables for analysis of the effect of a particular policy change. These variables may be quite different from one analysis to another. For one analysis, the modifiable variables may be tour duration and priority for determining fill of quotas; for another, policies pertaining to permissible flow. The third type of variable, the criterion variable, is the dependent variable--the output of model computation.

A major problem in the implementation of a particular manpower model is the determination of the appropriate criterion variable. The different applications of a given manpower model may call for different criterion indexes. Even for a particular military personnel management application, one or more of the following may be among the criterion variable: reenlistment rate, selection ratio for promotion, amount of reassignment turbulence, quality of fighting force, shortages of particular types of personnel, or reduction in attrition of potential leaders. Generally speaking, criterion indexes may be grouped into two categories--restriction criteria and maximization criteria. Restriction criteria are used in identifying infeasible policies; maximization criteria are used to identify an optimal policy or set of policies.

Alternative strategies are open to the research analyst when he is dealing with multiple criteria. Policies for which some of the restrictive criterion variables do not have values exceeding the respective minimum requirements (or have less than maximum permissible values) are considered infeasible policy configurations. Special attention must be given to situations where system output is evaluated by multiple criteria. In some situations, the trade-offs among the criteria may be fruitfully investigated. Disproportionate increases in one criterion value may accompany small decreases in another. Another possibility is that of nesting optimizations.[1]

[1] The term "nesting optimizations" refers to the establishment of a hierarchy of criterion variables in which the system is optimized with regard to the successively highest priority variable with feasible solution space reduced with each optimization. In other words, for each optimization the feasible solutions are restricted to those which do not disturb the optimization with regard to variables of higher priority.

It is of interest to analyze the significance of a discrepancy between the model criterion index and the criterion variable in the system being modeled. One contention is that the model is intended as a simulation of an ideal system. When this is the case, if the model criterion variable diverges from the system criterion index, the real system is at fault and should be modified to bring it closer to the ideal system--for example, when the variables represented in the model are manpower policies (as in some data-free models) and the discrepancy between model and real criterion indicates that the system is not operating according to officially prescribed policy. From the other point of view, the model is considered a representation or description of the actual or real system, in which case the discrepancy indicates lack of representation and is cause to modify the model and reconstruct the criterion sub-model.

USE OF MODELS TO APPRAISE THE DEPLOYABILITY PROBLEM

Under SIMPO-I, the U. S. Army Behavioral Science Research Laboratory has had responsibility for developing computer models for use in assessing the effect of alternative personnel policies on deployability.

Type of Model Required

Many assignment policies impose constraints on the ability of the Army to meet short-tour commitments. Others influence assignments to long-tour areas. In a June 1967 survey made from Preparation of Replacements for Overseas Movement (POR) reports, supplemented by information from travel orders and other sources, over 53% of the persons in the sustaining base were found not deployable to short-tour areas under assignment policies then in effect. A similar February 1968 report showed over 71% nondeployable to short tour. Of the thirteen separate categories of nondeployables shown on these reports, the five largest contained 85% of the total number of nondeployables. However, even the thirteen categories of nondeployability shown in the surveys are not sufficient to cover all the causes of individual nondeployability. Some categories contain persons nondeployable for many different reasons.

For complete flexibility of policy assessment with respect to deployability and its relationship to readiness, an entity network flow model is required. An entity model considers individuals and their associated characteristics. The individuals are moved through a network of nodes (states) according to assignment priorities and predetermined probabilities of movement, change, or loss. Some of the nodes represent duty tours; some represent temporary states or lags such as patient, leave, or student status. At each time step, complete updating of the system takes place with losses, gains, and reassignments simulated.

An entity flow model in which multiple characteristics are represented for each individual requires much more computer time than a mass flow model in which individuals are grouped by values of only two or three characteristics and in which flows occur by groups of similar individuals. File searching, sorting, and probabilistic loss routines used on a system of thousands of individuals are time-consuming as contrasted with the simply patterned movements and deterministic losses possible in the mass flow models. However, the entity model offers greater flexibility and more realism, since each individual may be considered with respect to all appropriate characteristics related to the decision being made.

When only a few aspects of nondeployability are affected by the policies under consideration, mass flow models may be appropriate for assessing the effects of policy change. At the present time, by using operational BESRL mass flow models, it is possible to assess the effect of such policies as lengthening short tours or service commitments, shortening the CONUS tour, substituting additional on-job training (OJT) for experience requirements, increasing the lag between individual training and first assignment, or changing the period of short-tour nondeployability for approaching termination of service.

It is possible to add limited additional complexity to an efficient mass flow model. However, a highly flexible mass flow model such as the General Matrix Manipulator being developed in the SIMPO project requires much more computer time than those with limited flexibility--five minutes per month as opposed to fifteen minutes for 60 months with DYNAMOD or three minutes for 60 months with the Career-Noncareer Model.

With these considerations in mind, it was concluded that the PRIMAR tools for evaluating the relationship between management policy and nondeployability should include both mass flow and entity models.

Suggested Model Output

In order to evaluate the effect of an assignment policy change, two computer simulations have to be made, the first to indicate the status of the system under current assignment conditions, and the second to indicate the system changes under a shift in policy. Output summaries list assignment policies used in the simulations and provide evaluations for each time period of interest, using appropriate criteria for evaluation of the changed policy. The criteria could be one or more of the following:

1. Possible manning levels for certain areas
2. Number deployable to the short tour
3. Total required subsystem size, or number forced out of subsystem
4. Percent of lower grade or cross MOS substitution required
5. Change in average time between short tours
6. Change in the number of men going to second short tour with insufficient time in base

Deployment Related Variables

1. Tour duration. It is management practice to limit the length of assignment in short-tour areas and to require longer interim assignment in other areas before issuing a second hardship assignment in order to maintain morale and to allow time for personnel development. However, arbitrary decisions on the ratio of short-tour and long-tour duration may require a much larger total system than necessary or anticipated.

2. Sequence of assignments. In an effort to distribute less desirable assignments equitably among members of occupational systems, men cannot be assigned directly from Korea to Vietnam or vice versa. Men with families cannot be assigned directly from Europe, Alaska, Hawaii, or Okinawa to Vietnam without delay in CONUS. Men in the lower grades are not moved directly from short tour to long tour. MAAG or Mission personnel are not sent directly to short tour when their tour is completed. The effect of such policies, even though they reflect thoughtful management practices, is to increase the number not deployable.

3. Duration of obligated service. Since inductees and enlistees may serve different terms of active duty, management might wish to determine the most effective tour length for each group. In constrained military systems, extensions may prove to be a quick source of experienced personnel; or early terminations may make room in a limited total system for additional trainee input.

4. Duration of training school. The effect of changing the length of basic and individual training on the number of persons available for assignment could be weighed against the relative efficiency of the force available. Elimination of certain courses or reduction of the number of students and instructors might change the deployability ratio.

5. Grade, skill, and experience substitution. Management may wish to evaluate the effect on deployability of changes in extent and type of substitution. Or it may wish to evaluate other deployability-related policies in terms of necessary substitution. Using nondeployability as a criterion, cross training from the MOS with surplus men to MOS with shortages might be considered. Given additional training, relatively inexperienced men might substitute for experienced men.

6. Duration of lag time between duty tours. Policies on temporary assignment between permanent assignments might also be evaluated.

7. Exemption from foreign service prior to ETS. In the interest of Army efficiency and economy, men nearing the expected end of their service are not sent to new foreign assignments. Relaxation of this policy may increase the number deployable, or cost considerations may require extension of the period of exemption.

8. Number and duration of stabilized positions. Within an assignment area, some jobs require a minimum duty tour. Changes in the number of jobs considered stabilized or in the length of stabilization could change the number deployable.

9. Other foreign service availability categories. Policies on exemption of men with certain characteristics may be changed, with resulting changes in the number of deployables.

10. Number of allowable unaccompanied assignments. Management may wish to consider the effect of allowing only one hardship tour in a specified period or during a specified term of a man's service. All system members might be required to share equally in hardship duty. Such policies would affect the number deployable.

11. Limit on repeated stabilized assignments.

12. Promotion requirements. Policy on promotion might be changed, with resulting change in the number deployable or the number in a given grade required for deployment.

13. Assignment priorities. Assignment of men according to a given sequence of priorities may lead to more nondeployables in the future than a different sequence.

SIMPO PRODUCTS: TOOLS FOR POLICY EVALUATION

The final SIMPO product is to include a series of computerized models which can be used to simulate several segments of the Army personnel system. These models are designed as tools to enable Army management to examine the effects of policy change. Because SIMPO is being developed during the time of the Vietnam crisis when the Army personnel system is subject to severe pressures from management rotation and assignment policies, it is natural that more consideration has been given to this area than to any other. Realistic simulation of the rotation/assignment system requires that policies affecting personnel transfer be explicitly represented in the simulation model or approximated in combination with other factors within the system abstraction depicted by the model.

SIMPO personnel have to date completed four mass flow models with which a limited number of assignment policies may be examined. A generalized matrix manipulator system has also been developed and a first level product tested. A specialized application of the General Matrix Manipulator has been adapted into another mass flow model which will offer extensive coverage of distribution related variables. One entity model has been developed and documented. Two additional entity models have been designed and are being programmed. The latter two entity models offer the ultimate in detailed coverage of variables planned in the SIMPO Work Unit.

The completed mass flow models have been used in examining the impact of certain policy changes on the ability of the Army to meet its commitments in the short tour. While these models are still useful, the more detailed models which are not yet (1 January 1969) completed will offer a wider choice of policies which can be considered. The newer models permit examination of distribution capabilities for other areas in addition to short tour.

Thus, SIMPO has not one model but several models to use in assessing the effects of policy change on deployability. The appropriate choice for a particular problem will depend on several factors:

The policy being considered, and how many related policy variants are to be considered.

The criterion variable--a measure of the enhancement or degradation of system performance.

The data base available.

How soon an answer is wanted.

Cost of computer time.

The policies covered in each of the mass flow rotation models are shown in Table 1. The models which have been completed and tested are DYNAMOD, ACCMOD, DYROM II, the Career-Noncareer model, and the General Matrix Manipulator. DISTRO, a specialized and extended application of methods developed in the General Matrix Manipulator, is in the final stage of development. As shown in the table, DISTRO will cover more possible policy changes than the other models. The earlier models, however, cover many policy changes which may be considered. Suppose a change in the duration of short tour is considered. Then any one of the models could be used. Or suppose a policy is being considered which would permit assignment of a man as an individual replacement within four months of his expiration of service date instead of the current six months. To evaluate such a policy, any model except DYNAMOD could be used if the system being examined fits the model in other respects. (ACCMOD depicts the noncareer enlisted system, DYROM II the career system.)

Table 2 shows the measures of system effectiveness available in the five models. Suppose the question under consideration is how many men are needed in a particular system under a given set of policies and what effect changing the duration of the rotation base tour will have on the number of men required. Any one of the models could be used if it represents the system under consideration, although under certain conditions DYNAMOD would distort system size. DYNAMOD can be used if the operations research analyst assisting the policy maker knows that the considered system fits DYNAMOD's capabilities; otherwise ACCMOD or DYROM II, the Career-Noncareer model, or DISTRO would be better.

If the criterion measure is the change in possible manning level resulting for the long tour, DYNAMOD or DISTRO should be used, since only in these models is the long tour depicted explicitly.

Table 1

POLICIES COVERED IN SIMPO MASS FLOW MODELS

Policy	DYNAMOD	ACCMOD	DYROM II	Career-Noncareer	DISTRO
Change Duration of Short Tour	X	X	X	X	X
Change Duration of Base Tour	X	X	X	X	X
Maintain Stabilized Assignments	X				X
Maintain Long Tour	X (one version)	Partial		of same duration as CONUS	X
Early Release	X (one version)	X	Easily Possible	Easily Possible	X
Retention Related	Partial	X	X	X	X
ETS Limits on Reassignment		X	X	X	X
Granting of Pre- and Post-O/S Leave		Pre	Pre	Pre	X
Catchall Temporary Affectors	X	X	X	X	X
Catchall Permanent Affectors		X	X	X	X
Substitution of Men from Lower Grades	Partial		Partial	Partial	Possible
Limit on Use of Inexperienced Men	X			X	X
Promotion	Possible		Partial		
Sequence of Use of Assets				Partial	Possible
Number of Short Tours Allowed				X	Possible
Amount of Training Output	X	X	X	X	X

Table 2

CRITERIA USED IN SIMPO MASS FLOW MODELS FOR EVALUATING POLICIES

Criteria Possible	Model: DYNAMOD	ACCMOD	DYROM II	Career-Noncareer	DISTRO
Manning Levels					
Short Tour	X	X	X	X	X
Sustaining Base	X	X	X	X	X
Stabilized Tour	X				X
Long Tour	one version only				X
Command Elements					X
Length of Base Tour	X	X	X	X	X
System Size Necessary		X	X	X	X
Number Early Returns to Short Tour	X	N/A	X	X	X
Turbulence		X			
Required Substitution			X		

Table 3 shows input rates required by the simulation models. SIMPO has required the model user to furnish system rates for the simulations.

In Table 4, an effort has been made to show the relative difficulty of using the five models. ACCMOD and DYROM II use a gross data base which is preprocessed in the computer according tö rules agreed upon by the present model user and the model builder. The remaining three models use a starting data base for which the necessary detail has been supplied before data are input to the computer. ACCMOD, DYROM II, and the Career-Noncareer model depict two tour categories, and shortcut some of the methods used in DYNAMOD; they use less computer time and can be quickly prepared for a rerun, but they cannot be used to depict a separate long tour or stabilized CONUS tour as can DYNAMOD or DISTRO.

The present discussion has pointed out that several SIMPO models are available to assess the effects of policy change on deployability, but that choice depends on important considerations: the systems being examined, the policy being considered, the starting data available, the urgency of obtaining an answer, and the cost of computer application.

Table 3

INPUT REQUIRED FOR SIMPO MASS FLOW MODELS

Input Required	Model: DYNAMOD	ACCMOD	DYROM II	Career-Noncareer	DISTRO
Attrition					
For Each Subtour	X				X
For Kinds of Personnel (component, career status)		X	X	X	
Casualty					
Permanent	X	X	X	X	X
Early Transfer		X	X	X	X
Nondeployability					
Permanent		X	X	X	X
Temporary	X	X	X	X	X
Retention	X	X	X	X	X
Short Tour Usage of Training Output	X	X		X	

Table 4

COMPARISON OF SIMPO MASS FLOW MODELS AS TO EASE OF USE

Utilization Factor	Model: DYNAMOD	ACCMOD	DYROM II	Career-Noncareer	DISTRO
Input Required					
Summarized Inventory Available from Current Reports		X	X		
Detailed Inventory Available on Tape Records	X	X	X	X	X
Complexity of Original Input	Moderately Complex	Easy	Easy	Moderately Complex	Very Complex
Reruns (vary according to changes--for example, short tour requirements)	Moderately Complex	Very Easy	Very Easy	Easy	Moderately Complex
CDC 3300 Running Time per Sample	15min/ 60mo	1/2min	1min	3min/ 60mo	5min/ 1mo
Months in Projection	Variable	24	24	Variable	Variable

Table 1 is not a comprehensive coverage of all policies which might affect deployability. The entity models will make it possible to consider almost any deployment-inhibiting variable if a starting data base containing the variable can be supplied and if the relation of the variable to assignment practice can be fully described. Under a SIMPO contract, a general entity simulator is being prepared which will have applications including rotation, promotion, and cross-training. As a first application of the General Entity Simulator (GES), the Aviator Entity Model covering the Army Aviator System is nearing operational capability. This model will be useful in any officer rotation system and possibly for some enlisted MDS systems. With the termination of the contract early in 1969, additional specific system applications will be made by BESRL. The concept around which the GES is being designed calls for the contractor to provide a simulation mechanism, to be followed by the development of specific system models and appropriate input routines by BESRL personnel.

Another entity model which was developed to assess policies concerning the limited area of first assignments has been tested and is available for use at BESRL.